FLIGHT OF STS–2 WITH ASTRONAUTS COLONEL JOE ENGLE AND CAPTAIN RICHARD TRULY

HEARING

BEFORE THE

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FLIGHT OF STS-2 WITH ASTRONAUTS COL. JOE ENGLE AND CAPT. RICHARD TRULY

WEDNESDAY, DECEMBER 9, 1981

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C.

The committee met at 9:50 a.m., in room 2318, Rayburn House Office Building; Hon. Don Fuqua (chairman of the committee) presiding.

Mr. FUQUA. The committee will be in order.

Without objection permission for photographs, recordings, and television coverage will be granted.

This morning the members of the Committee on Science and Technology are honored with the opportunity to welcome two of America's latest heroes, Col. Joe Engle and U.S. Navy Capt. Richard Truly. Both Colonel Engle and Captain Truly were awarded the NASA Distinguished Service Award by the President on Monday. We certainly want to congratulate you on being recipients of that award. Your courage and achievements made the second mission of the Space Shuttle *Columbia* spacecraft a successful mission even though it was abbreviated.

The successful launch of STS-2 on November 12 was a very historical event. It marked the first time that a space vehicle was reused after achieving orbital flight, and its OSTA-1 payload also marked the first delivery of science and space applications experiments into orbit by the Shuttle, and it also represented the first use of the Spacelab pallet developed by the European Space Agency.

Accompanying the crew today at the hearing is Phil Culbertson. Phil is a longtime NASA employee and was just appointed Associate Deputy Administrator of NASA. Phil, we want to congratulate you on that appointment and look forward to working with you in that capacity.

Before we get started, I would like to take a moment to introduce two other people who are here that I think deserve a great deal of credit, and that is Mrs. Mary Engle and Mrs. Cody Truly. [Applause.]

At this time I would like to recognize Mr. Flippo, the chairman of the Space Science and Applications Subcommittee. He's probably about the second best chairman that that subcommittee has ever had.

Mr. FLIPPO. I appreciate those remarks. Considering the fact that I think there have been three subcommittee chairmen, I'll be de-

lighted to have second place in that. Or even third among that group.

Mr. Chairman, we are not only honoring these gentlemen here today, but I am sure they would be the first to join and agree with the statement that we are also honoring those thousands of people who have contributed and worked very hard on this program.

The program has many unsung heroes. The Shuttle will open up a new era in space transportation which we will have an opportunity to exploit for all mankind. It represents an expansion of capability that will challenge our very imagination to take full advantage of, and I think the gentlemen here today will contribute a great deal toward assisting the executive branch and the Congress and the American people in looking very carefully as a nation as to what our future goals should be.

It's a great personal pleasure to have you here today.

Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Winn is tied up in a meeting of the Kansas delegation and is being detained a few minutes about a very important matter.

At this time I would like to recognize the ranking minority member of the Space Science and Applications Subcommittee, Mr. Hollenbeck.

Mr. HOLLENBECK. Thank you, Mr. Chairman.

I too would like to welcome Joe Engle and Dick Truly to the committee and I look forward to their overview of the mission. I, like my colleagues on the committee, gentlemen, take pride in your accomplishments with the second launch as we continue to maintain our leadership position in space exploration.

As the chairman said, you are to be commended for your service in the program and I congratulate you along with the chairman and the subcommittee chairman on the several achievements of goals that were attempted or were sought for the first time.

Mr. Chairman, I would like unanimous consent to extend my remarks at this point in the record.

Mr. FUQUA. Without objection.

[The prepared statement of Mr. Hollenbeck follows:]

STATEMENT OF HON. HAROLD C. HOLLENBECK

I, too, would like to welcome Joe Engle and Dick Truly to the Science and Technology Committee and I look forward to their overview of the STS–2 mission. I, like my colleagues on the committee, take pride in the accomplishments of the second launch as the United States continues to maintain its leadership position in space exploration. You are to be commended for your dedicated service to the Space Shuttle program and I congratulate you for several achievements of STS–2 that were being attempted for the first time. Among these noteworthy firsts are: The same space vehicle was launched into space and safely returned; a payload, OSTA–1, was placed and operated in the orbiter; and, a remote manipulator system was deployed and tested.

These are just a few illustrations that underscore the progress being made in the Space Shuttle program. Of further significance was your ability to complete approximately 90% of your high priority flight test objectives in only 54 hours of a scheduled 124-hour mission.

The members of this Committee stand ready to continue to work with NASA in fostering additional advances in U.S. Space Transportation Systems. The U.S. Space Program has progressed from putting a man in space in 1961, to landing on the moon in 1969, and I look forward to the Space Shuttle program to usher in a new era of advanced space technology.

Mr. FUQUA. At this time, Phil, I am happy to recognize you. Welcome again to our committee.

STATEMENT OF PHILIP CULBERTSON, ASSOCIATE DEPUTY ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JOE ENGLE AND RICHARD TRULY, ASTRONAUT CREW STS-2

Mr. CULBERTSON. I have been before this committee and the subcommittee many times in the last 10 years. There have been good times and there have been bad times; however, it's nice to come back to start a session where we are going to tell you what it was all for. I hope we will be back many times to add to today's discussion of the Shuttle to explain how it operates and what it is capable of doing.

It is a temptation for me to describe something about the mission, but, I think, that would be a bad mistake. The best thing that I can do is to introduce the two men that you came to hear and see, and let them tell you what it was like firsthand. That, after all, is the right way to hear about an accomplishment like the second flight of the Shuttle.

Dick and Joe, as you recall, were pilots during the approach and landing tests. We were talking about that just this morning. Four years seems like a long time ago, but it was in 1977 that we first flew the orbiter *Enterprise*, piggy back on the carrier aircraft initially and then in free flight. So, Dick and Joe were old hands even at the time of the STS-2 liftoff last month. They were the most experienced Shuttle crew that we had. Therefore, it's a great pleasure on behalf of NASA to introduce the two crew members who flew STS-2, Col. Joe Engle and Capt. Dick Truly.

Colonel ENGLE. Thank you very much, Phil. Mr. Chairman and members of the committee thank you very much for letting us be here to share with you some of the experiences that Dick and I enjoyed and participated in on the second flight of *Columbia*.

The most important thing, I think, that we can say is: "Thank you very much for making it possible for our Nation to have been able to develop something like this flight and this vehicle. This country, through your help, has, indeed, develped the most fantastic piece of machinery imaginable. The Shuttle is going to provide us with the capability to get to the new frontier of space, to take advantage of that frontier, to get up there efficiently and economically, to be able to take payloads up and bring them back, and to operate in an environment where our minds need to start becoming exercised until we know how to take advantage of that new frontier. Other nations are going to try and some are doing it now. We certainly have the jump on them with this vehicle. I would like to echo Mr. Flippo's remarks on thanking everyone who was involved with making the program possible. It's hard for me to find words other than to say that we have a fantastic machine to do the job that we set out to do. It operated beautifully in all phases of flight.

On our flight we had four major objectives. The first objective and probably the most important, was to demonstrate the ability to reuse a spacecraft, and *Columbia* certainly demonstrated that capa-

bility 100 percent on this flight. Second, we wanted to demonstrate the remote manipulator system, which was done completely. Third, we wanted to obtain data for the OSTA experiments package, primarily Earth resources, to demonstrate the feasibility of being able to conduct experiments and tests so that we will be able to take advantage of that platform and that vantage point in space. The fourth objective was to begin the aerodynamic and the aerothermodynamic verification flight test program on the Shuttle.

I'm very happy to say that all four were completed even though we were compelled to terminate the mission after 2 days instead of 5 days. We were not really thrilled about having to cut back from 5 days to 2 days. Both of us would rather have stayed for 5 days; but, I think, on the other hand, this is probably the wrong place to look for sympathy because I understand you all are going through those kinds of things yourselves.

I would like Dick to say a few words first and then we would like to share with you some of our experiences.

Captain TRULY. Mr. Chairman and members, I would like to echo Joe's remarks. In looking at the data from the STS–2 mission, despite the fact that it was somewhat shortened, we believe that we have learned more from the mission by demonstrating an alternate flight plan, a much higher workload, and that the orbiter, *Columbia,* could perform its mission under these trying circumstances, probably more than it would have had had we flown 5 days.

I would also like to comment that, I believe we are at a springboard for opportunity in the program. This is not the day to stop to make heroes out of the astronauts or the thousands of people that are so deserving throughout the Government and the contractors; but, today is the day to look at what we have done. We have demonstrated the reusability of the Space Shuttle. We intend to fly the third flight on the same flight plan, incidentally, that we had planned prior to the first flight, which, we believe, is quite an achievement for flight tests.

We would like to spend a few minutes this morning telling you about the flight itself. We have a short movie and some slides of the Earth that we think you may enjoy.

[Movie presentation.]

Colonel ENGLE. Our launch occurred with a full moon. At least our first launch attempt had a full moon. We were looking forward to flying with a full moon, but we, of course, had to delay a week and ended up with somewhat less.

Some of the technology that NASA has discovered, radar that looks through clouds and all, they've also discovered this camera that looks right through the hairline. We certainly didn't want to demonstrate that on this flight.

Captain TRULY. This is the main engine ignition. We really benefited by the advice and counsel of John Young and Bob Crippen who flew the first flight of the *Columbia.* As they had described, the main engine operation was very smooth. You can see the engines gimbaling there. There the bolts are blowing and the solid rocket motors are igniting. When the solids ignited there was a very loud staccato type sound. However, Joe and I were able to talk to each other in a normal tone of voice on the intercom all the way up.

This was really a thrilling moment for us.

Colonel ENGLE. We certainly weren't inhibited from either reading checklists or instruments during this vibration, but it certainly was apparent when the main engines were burning. If you'll look closely you'll see that the vehicle passes through a very thin cloud deck. I'd like you to keep that in mind in the next sequence in which you'll be looking out Dick's right-hand window. I don't think he had the privilege of looking out that window during launch; but, this is what Dick could have seen if he'd looked out to his right. If you'll lay your head on your left shoulder you'll get the right perspective of this picture. I'll let Dick describe what you're seeing as you come up.

Captain TRULY. You can see the Atlantic Ocean lapping on the Florida beach. There's the roll maneuver. This is twice real speed. There's the curving north coast of Florida. As we got up midway through the first stage, we both noticed that the sky began to turn from a pretty blue to a dark blue and finally black. As a matter of fact, before this scene is over you will see, just in the center of the horizon, a couple of stars rising. We could see the stars even in powered flight as long as we shaded our eyes from the sun.

Colonel ENGLE. If you'll watch, you'll see a star come up over the horizon, right there.

This sequence was taken from our T-38 chase plane that was overhead orbiting. In case we did have to abort and return to the launch site, he was there ready to join up, look the vehicle over, and make sure that we were in good condition to land.

Captain TRULY. After the solid rocket motors had staged, the flight—of which this is a beautiful view and you can still see the three main engines burning—on the main engines was very smooth and very quiet.

Colonel ENGLE. It was certainly spectacular when the solid rockets were jettisoned away from the vehicle. There was a big flash of fire and smoke that extended across the wind screen. Although there wasn't time to worry about it at the time, it certainly did get your attention.

Captain TRULY. This is a good view of the separation of the external tank after main engine burnout. We are now turning away from it. The tumble valve on the external tank is working and you'll see the vehicle pitch over.

Colonel ENGLE. The dark areas on the tank are the result of aerodynamic thermal heating from shock waves in the front part of the tank, exhaust from the solid rocket motors that jettison the tank away, and probably from back flame from the main propulsion systems on the back side of the tank during the boost.

Captain TRULY. We have a number of scenes now from our work in orbit. I know you sent us up there to work all the time, but we just couldn't stand not being tourists. Looking out at the beautiful view of the Earth, I'm sure that you've heard many an astronaut use the words fantastic, beautiful, super, marvelous, but we can't improve on those words.

Colonel ENGLE. This is a sequence of Dick opening the payload bay doors. This is the port, or the left, door coming open. These are the radiators that expel heat. We circulate freon through these radiator panels and that rejects heat back into deep space from the

avionics equipment on board. This is the remote manipulator system, or the big arm, laying right across the left-hand side of the vehicle.

In the center of the bay, there's the OSTA–1 experiment package sitting on the pallet that flew for the first time. The large radar dish shown is the Shuttle imaging radar. It's a synthetic aperture radar that we'll show you in a couple of data slides later.

There's the prettiest view of all—the Earth.

Beyond a doubt, the most spectacular thing that we saw and experienced through the whole flight was to look back at the Earth and just become totally inspired and awed by the perspective that was available.

Captain TRULY. The remote manipulator system built by Canada flew for the first time on this flight. During the flight, even though it was abbreviated, we managed to put the arm through each of its automatic and manual modes. We are leaving this country to make a visit to Canada starting tomorrow morning, and we can predict for you that we will very proudly and truthfully say that they deserve to be proud of this magnificent piece of equipment that they have flown for the first time on this Shuttle flight.

Colonel ENGLE. This sequence is looking from the camera located at the elbow of the arm looking back at the vehicle, and it shows portions of the wing of the vehicle.

Captain TRULY. This manipulator system is intended to be used to deploy payloads or even to capture satellites that have failed in orbit in order to be able to repair them. The next flight will actually grapple two different payloads and perform some experiments in the general area of the orbiter itself.

Colonel ENGLE. This is Dick operating the remote manipulator system from the front part of the cockpit looking aft. This is looking out the window that was right over his shoulder. In this particular sequence he is maneuvering the arm into a simulated grapple target, which we had on board, to demonstrate the feasibility of actually picking up payloads out of the payload bay and placing them out into orbit.

Captain TRULY. A good measure of success of the arm, even though we had to abbreviate the time for testing the arm, is that we did get to check it out in all its modes. The next Shuttle crew, Col. Jack Lousma and Col. Gordon Fullerton, is planning to use the arm in essentially their originally planned flight plan. They will pick up a few steps out of a few procedures that Joe and I did not have time to get, but that will take probably less than a couple of hours in their 7-day flight.

Colonel ENGLE. The arm is configured very much like the human arm. It has a shoulder joint, an elbow joint, and a wrist joint. The wrist joint moves in three axes—pitch, roll and yaw. The shoulder joint being here, the elbow joint here, and the wrist joint located out in this position. In this sequence, Dick has straightened the arm out to bring it back down into its cradling devices.

Captain TRULY. This particular mode of the arm is the backup mode. You'll notice the very lightly damped oscillations as we made small inputs in order to dock the arm. This is not the normal mode of operation for cradling the arm; therefore, this particular phase should not have to be done on a subsequent flight.

Operations in the aft deck of the orbiter were very easy. We predict payload operations in the future, whether the arm is on board or not, are going to be easy to train for and easy to accomplish.

Mr. FUQUA. We have a vote and we've got 5 minutes now to make it. If we could stop this film, we'll run and vote and come back. I warned you about this. I hate to interrupt.

Colonel ENGLE. I think that would be fine.

[Recess.]

Mr. FUQUA. If the members will take their seats, we will be in order.

We will resume now where we had to interrupt a few minutes ago.

Captain TRULY. To resume, because of the shortening of the flight we didn't have time to stage a lot of TV and documentary photos, so Joe set up a television camera down in the mid-deck. This is us eating supper, with me upside down that night and Joe right side up.

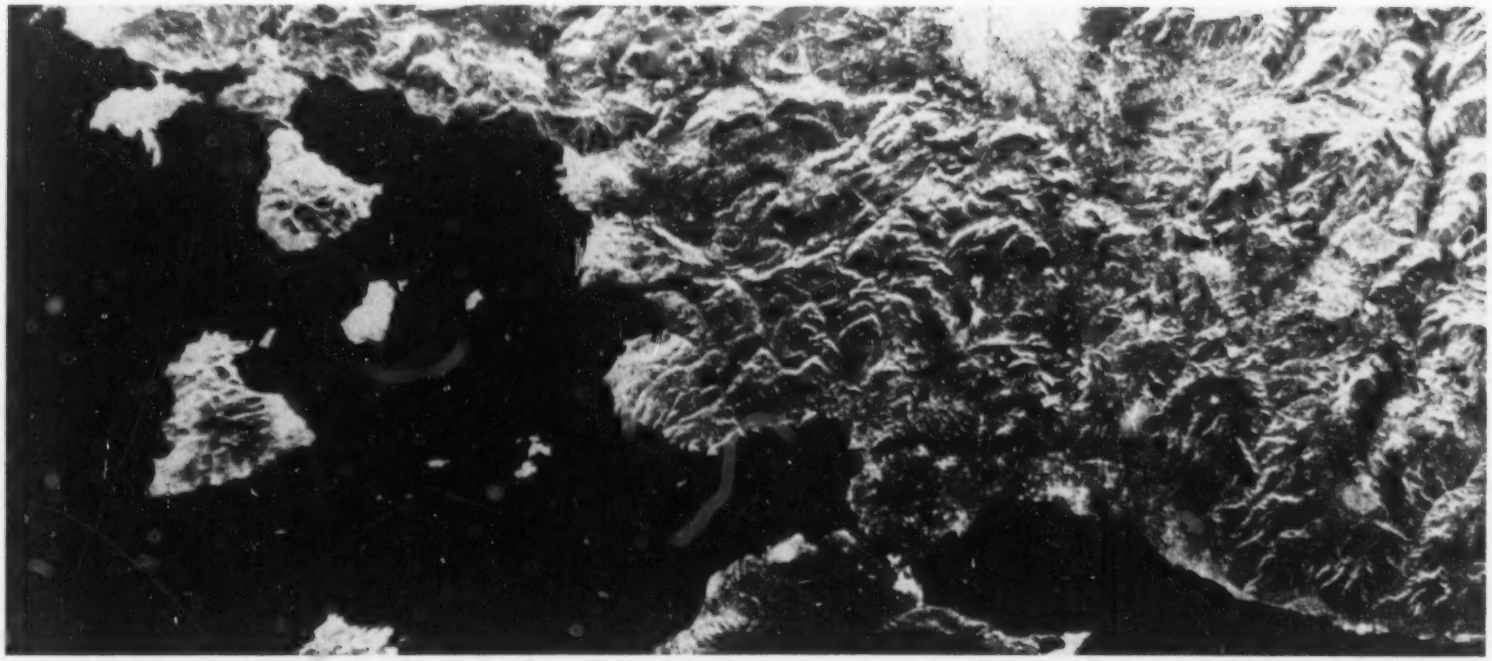
Colonel ENGLE. It's a little variety that everyone ought to try at home for supper some night. Zero gravity is such a refreshing environment. It's so easy to move around. There's a book that we've just set out there in the middle of the mid-deck and it's floating by itself. There comes Dick floating by, to give you an idea of just how easy it is, and fun, too, although we hate to admit to anybody how much fun it is. But it is so much fun to move around in zero gravity. It takes very little time to adapt to an environment without gravity. In fact, it was a little more unique and more noticeable for me to re-adapt to 1-G environment after landing on Earth.

Captain TRULY. One thing that was very heartening to us—of course, we were a couple of rookies on this flight—but we discovered what the old veterans have known for a long time—and that is operations in the cabin in zero gravity are very easy and will make future operations of the Shuttle really nice.

Colonel ENGLE. One of the experiments that we had on board was the nighttime/daytime optical study of lightning. Although the mission was shortened and we were unable to get a lot of opportunities to take pictures of thunderstorms, what meteorology we had prepared ourselves for was fascinating to us to watch the storms develop around the country.

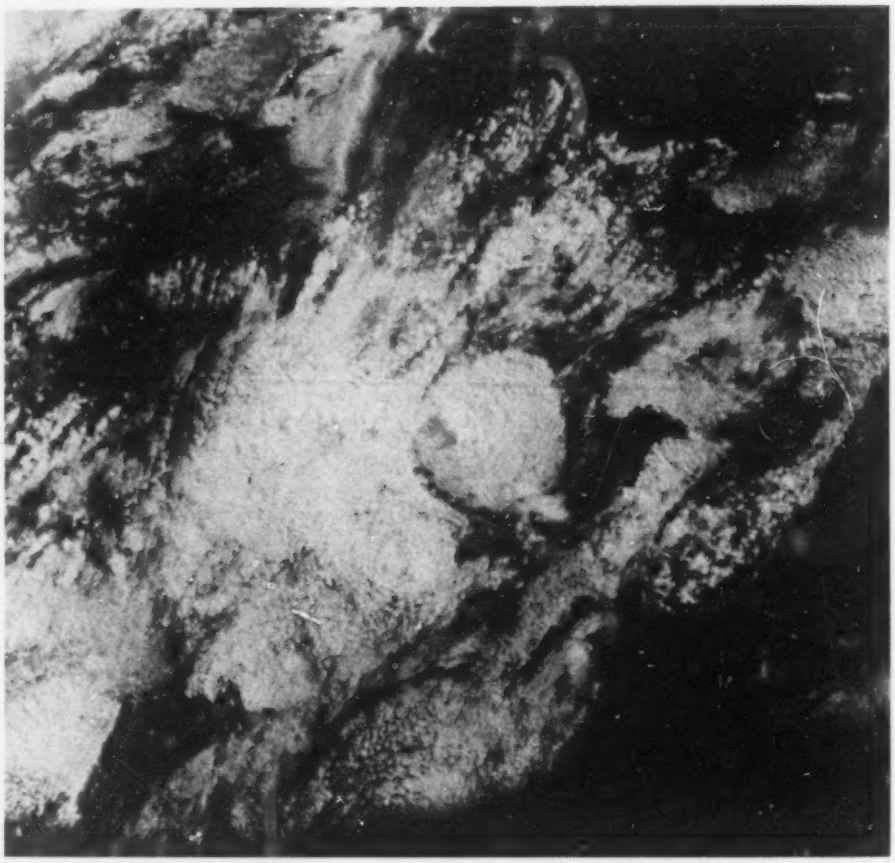
These are some big thunderstorms embedded in cirrus clouds. They push up through the tops of the clouds and are fascinating to watch.

We've another still photograph, that we would like to show you a little later on, but we'd like to get into our slides now.



Slide 1

Captain TRULY. This is a map of the world, slide 1. The red tracks are those tracks where the Shuttle imaging radar attained data on this flight. As we said before, the flight was shortened to just over 2 days. However, of the 3,600 feet of film in this radar, all but a very few feet was exposed and is now being processed at the Jet Propulsion Laboratory.



Slide 2

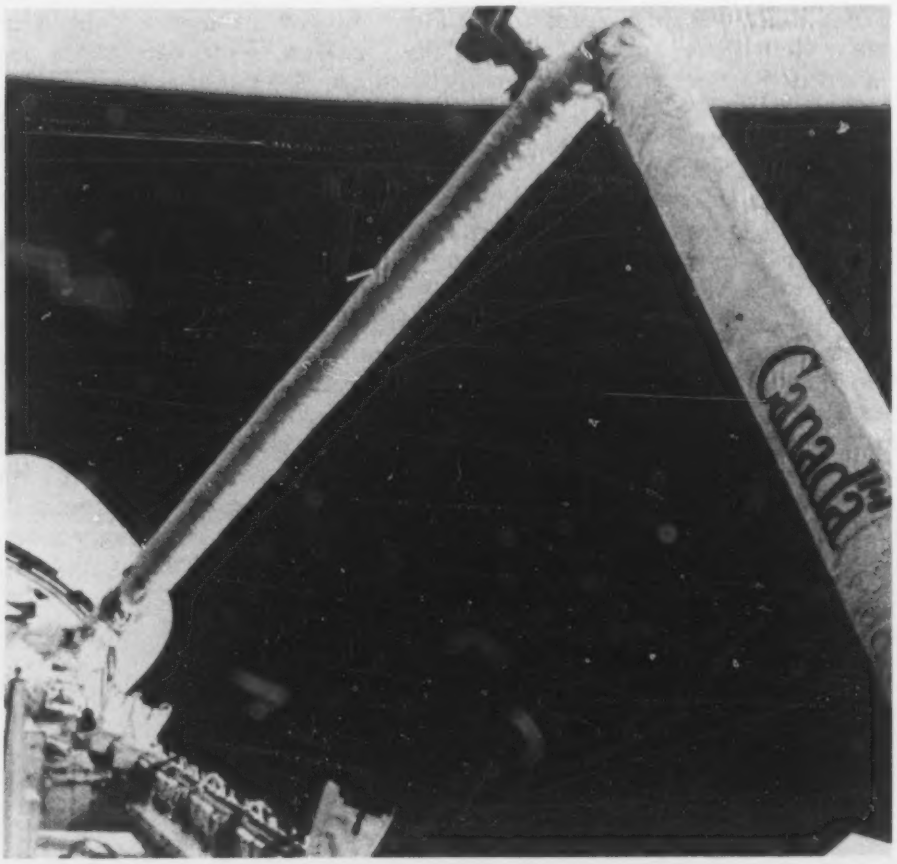
Captain TRULY. This is an example [slide 2] of an image of the Shuttle imaging radar. This land mass is in southern Greece. That bright spot is the city of Corinth. If you look very closely, you can see the canal crossing the isthmus there. As you know, the synthetic aperture radars, or side-looking radars as they are sometimes called, can operate day or night through any weather. The bright spots on the picture are cities. The reason they show up brightly is because in urban areas there are so many sharp corners, buildings, and streets that the radar sees a large return. The natural portions of the picture are reflecting off the terrain itself.

This is in western Australia [slide 15]. There are a couple of large volcanic features with granite centers. You can even see modern day rivers that are flowing through the general terrain.

Colonel ENGLE. The advantage to the geologists and people who are studying earth resources is that the imaging radar can look at night and look through not only clouds, but through all kinds of vegetation including trees and forests and even down to the bedrock to expose the kinds of outcrops and exposures to give us a feeling of where mineral and oil deposits are located.

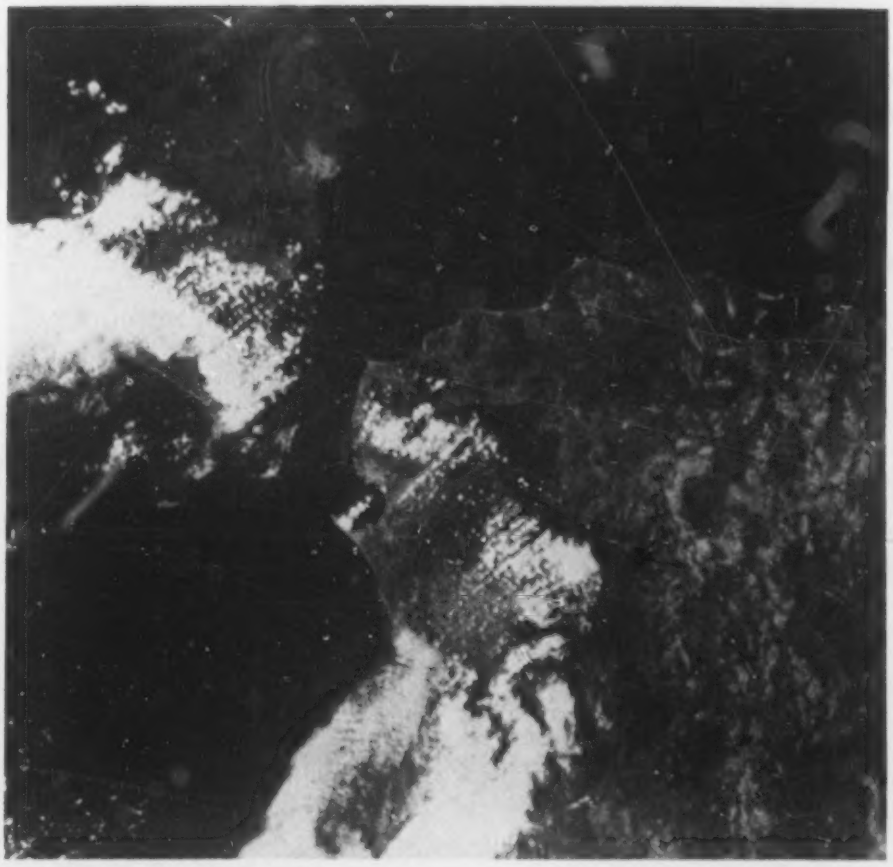
Captain TRULY. Joe and I would like to take credit for this radar performance on this flight, but we really can't do that. That performance was due to the tremendous operations in Houston of our payload operators. This flight was a ground-commanded experiment flight, except for a few times that Joe commanded the experiment on and off during the time that I was doing the arm work.

Colonel ENGLE. Thunderstorm development was one of the things that we mentioned previously as well as how interesting it was to watch these storms as they built up. It looked as if somebody were down under this bunch of clouds with a can of shaving cream, pointing it straight up and trying to build a pile up here on the top; but, it would spill out and pour out to the side. It's fascinating to watch weather develop from on top.



Slide 3

Captain TRULY. This is a photograph [slide 3] of the arm that Joe took looking out the aft window.



Slide 4

Captain TRULY. This is a beautiful picture [slide 4] of the Straits of Gibraltar. The Rock of Gibraltar is right there under that little cloud formation.

This is Africa and Spain. There's Naval Air Station Rota, Spain, just at the north side of that bay there. And down right there is the city of Cadiz, Spain.

The city of Tangier is down in this area. On the original photograph you can even see the deep water piers.

We think these photographs are beautiful; but, frankly, after looking at the earth with our eyes, we'll have to tell you that we now think they are kind of lousy. The human eye can see so much more detail and so many more hues of color that it's really an exciting personal experience to fly in space.

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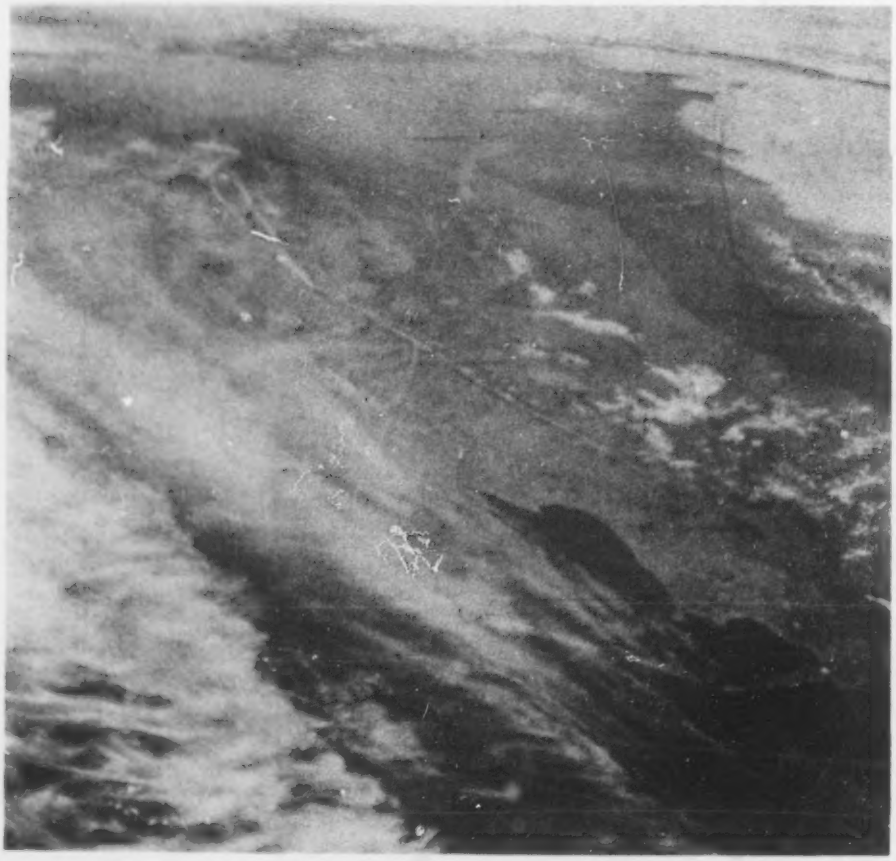
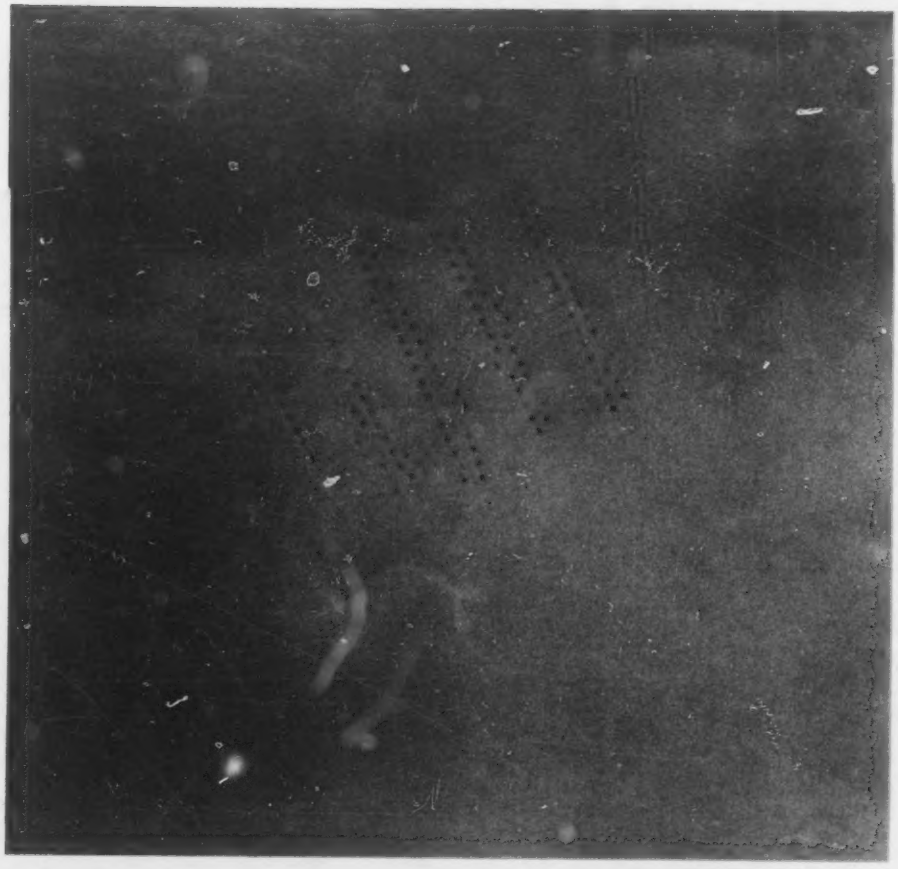


Slide 5

Colonel ENGLE. It's amazing the kind of detail [slide 5] that you can see from space. Again, like Dick says, the lack of detail as it diffuses on pictures as you try to show or relate them.

This falls in the category of interesting things that we saw. This is Italy. The Adriatic Sea is in this area. With the boot of Italy is down in this area here. Rome is located about in this location.

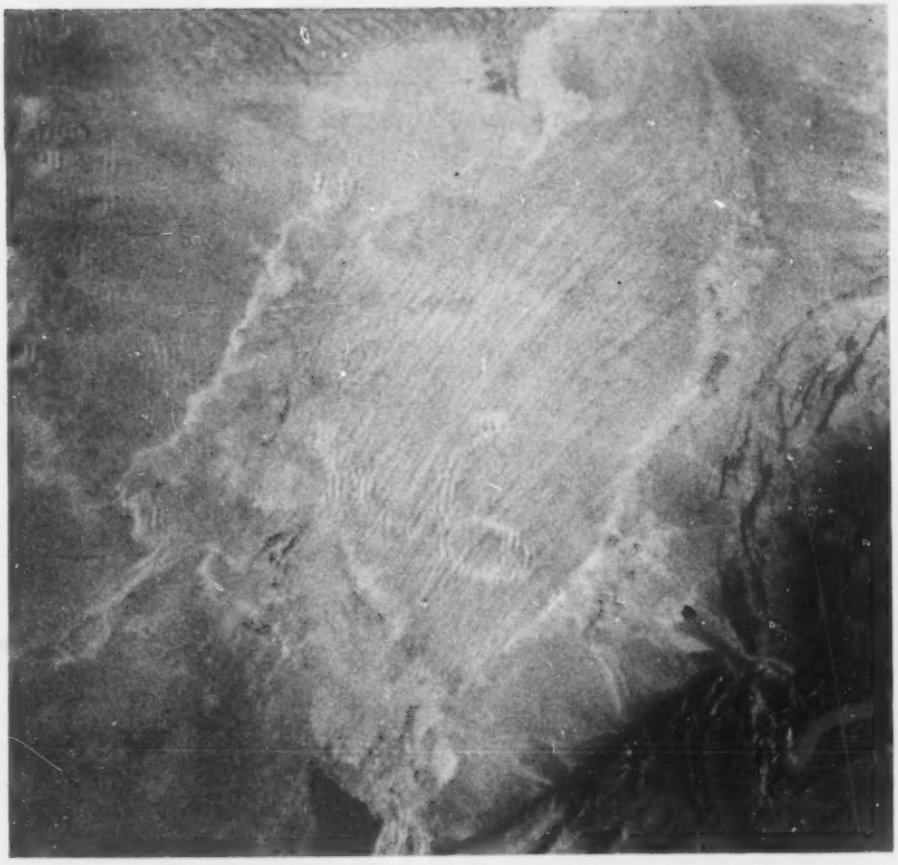
This was something that we saw a couple times in two successive passes and thought it was tremendously interesting. The long white lines coming down in the picture, you'll notice one of them branches off and comes down this way, are contrails from jet airliners coming down from Europe across Italy. They obviously mark the locations of radio navigation devices on the ground. There's one navigation device there. You'll notice two aircraft homing in on that one navigation facility, both of them flying the same air route down to apparently another navigation facility here; and, then one of them breaking off and going down in North Africa with the other continuing into southern Italy.



Slide 6

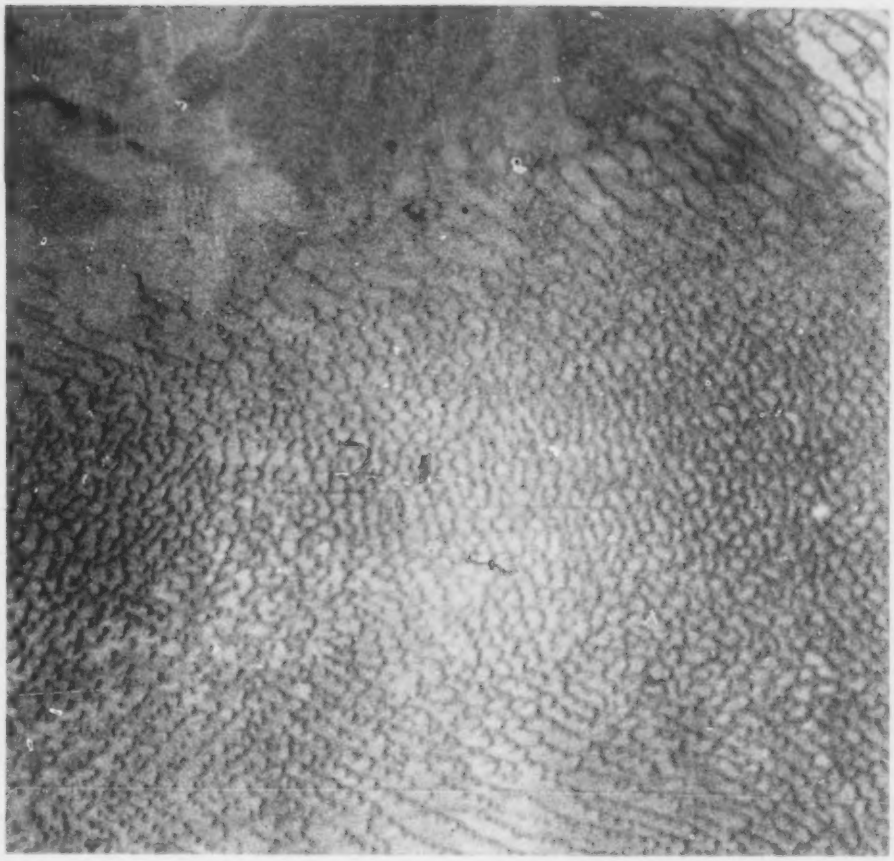
Colonel ENGLE. We quite frankly didn't know what we were looking at when we saw these things [slide 6]. We made a couple of passes and saw them a couple of times and photographed them. They are dark, circular objects out in the middle of a vast desert in eastern Libya. This area is located about 300 miles southeast of Bengasi.

After we were on the ground, we found out that this was an attempt by the Libyan Government to raise sheep in the middle of this desert. They had discovered underwater resources out there, drilled and pumped the water up to circular irrigation devices to grow alfalfa much the same way that we do out in the western part of our country with these large, circular irrigation devices. They don't harvest the alfalfa, they raise the sheep on these fields, periodically moving them from one field to another. When the sheep are grown, they are taken over to these long strips, which are airfields, loaded aboard airplanes and flown to Tripoli. Economically, it's a disaster. Libya could import the sheep from Greece at a fraction of the cost, but it's one of those things that they decided they were going to make happen.



Slide 7

Colonel ENGLE. This is in the eastern part of Iran [slide 7]. This is a very large lake bed, approximately 60 miles by 40 miles. It's a very hard sand lake bed, almost sandstone. If you'll notice, there are gouges that are cut out in the rock. These gouges are made by prevailing winds that blow sand across, thereby etching deep gouges about 50 feet deep. They are called yardangs. It's a tremendously interesting thing to see from the air.



Slide 8

Colonel ENGLE. In the eastern part of Saudi Arabia [slide 8], there's an area called the empty quarter. This area is several hundred miles across and is covered with gigantic sand dunes 200 to 300 feet high with the sand dunes interconnecting. The significant thing about that is that these sand dunes are held at an angle, their maximum angle of repose. What that means is the steepest angle in which sand of a certain size and grain could be piled and not cause the sand to come tumbling down. That sets up a situation where there is no way to get across this area by foot. If you try to cross or climb one of those sand dunes, you start a sand avalanche, if you will, and become immediately buried by this huge avalanche of sand. Until the advent of helicopters, no one could get into this area. Since then Saudi Arabia has discovered oil resources in there and eventually will tap that oil. But still, there is no way to cross on land.

Slide 9

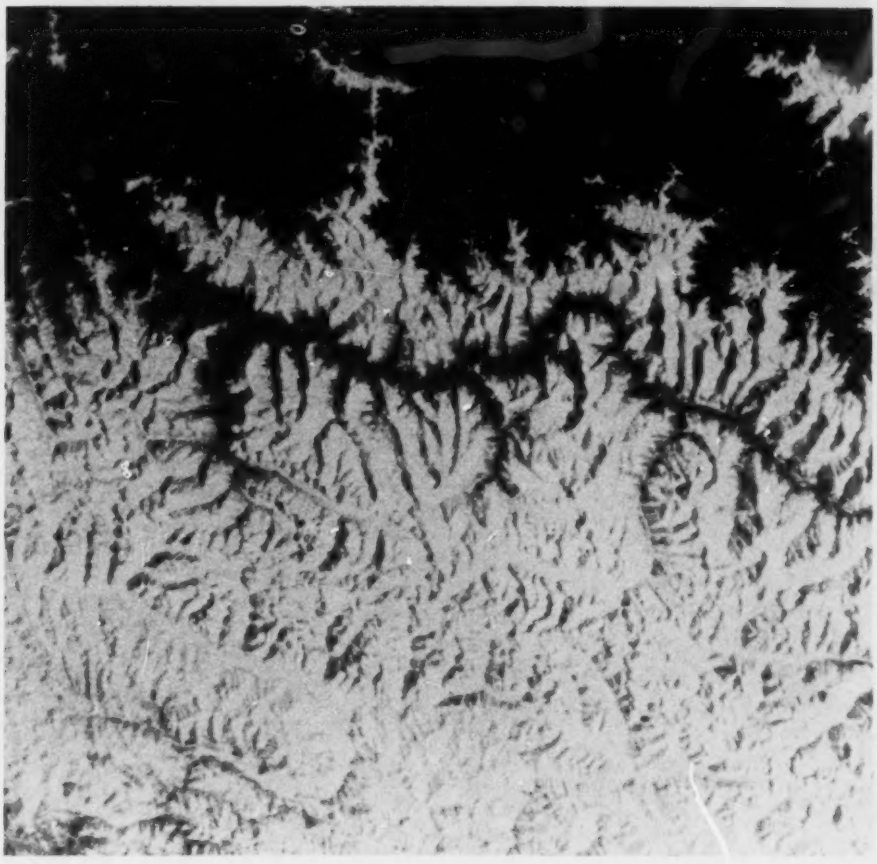
Colonel ENGLE. To me, one of the most fascinating things would have to fall in the category of perspective obtained from that platform of space. We've all heard about the continental drift theory, which I think it is becoming more and more popular—the idea that large land masses are continually moving and shifting their position on the Earth. This picture [slide 9] is looking toward the northeast. This area is Pakistan, and the area over to the right is India.

India is moving to the north into Asia at a rate of about 4 inches a year. The Continent of Asia and India, being heavier rock, are diving under the Asian rock, forming the Tibetan plateau and at the bow forming the Himalaya Mountains. The Himalaya Mountains, or what used to be the Himalayas, used to go straight across from this point straight across India to the east, but just like a ship goes through the water and forms a bow wave and a wake off to the side, India is going through Asia, diving under and forming the bow wave. That bow wave is the Himalaya Mountains; the rise out in front, which is the Tibetan plateau, and the wake on the side are the rocks that have been pushed, shoved, bent, and twisted.

That is really spectacular from space. You can really see it happening. Every time we'd orbit, India would be moved a little bit farther over. You could tell it. In fact you had to set the shutter speed pretty fast. Since it's moving so fast, India is a little bit blurred here.

S14 - 10

Captain TRULY. This is the Persian Gulf [slide 10]. One of the most politically talked about points in the world is this very narrow Straits of Hormuz where the large tankers take so much oil from this area of the world to almost all other areas of the world. This is an interesting feature for oceanography. You can see the strange cloud formations that are mapping beneath the large, circular eddies that are out in the Gulf of Oman.

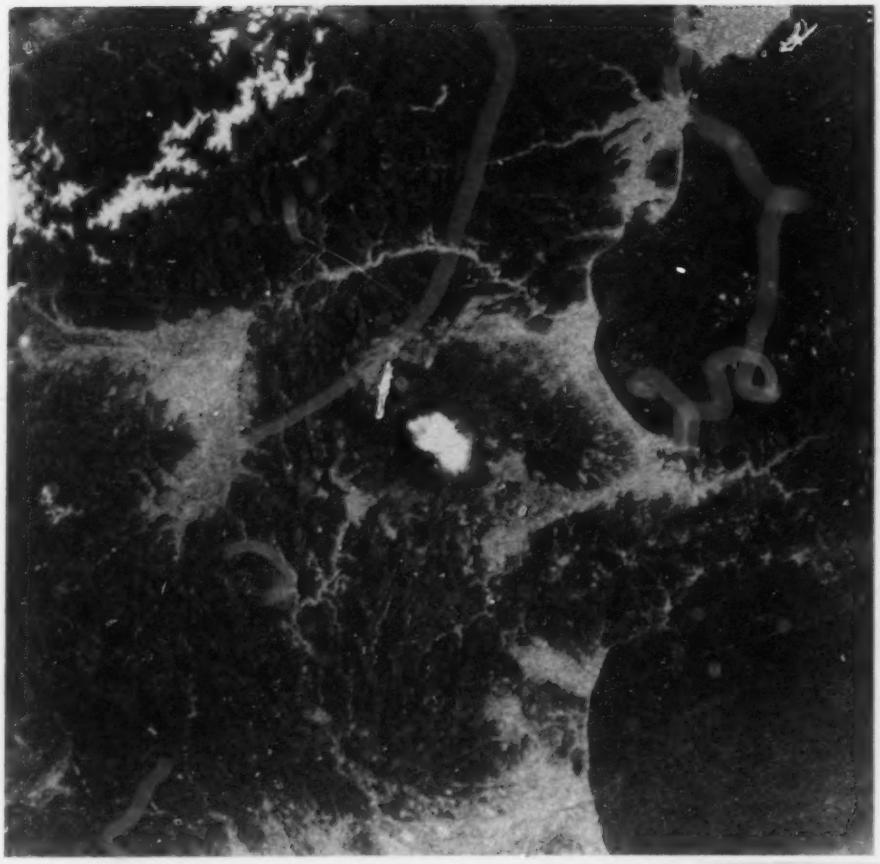


Slide 11

Captain TRULY. By far, the most beautiful sight to my eyes was looking down on the Himalaya Mountains [slide 11]. This is the southern front of the Himalayas. You can see a large, deep river gorge going through. The snow line here is about 12,500 feet.

This is also in the Himalayas [slide 12]. This is a large chain of lakes in the region of the Himalayas where China, India, Kashmir, and Tibet come together. There are many border disputes in this area. The snow is generally dropped to the left side of the screen. Actually what looks like low desert here is also high; but it is only that the clouds have formed in the prevailing wind and have dumped the moisture out to the east. Several of the world's highest mountains are in this photograph.

Colonel ENGLE. Dick mentioned that there are several borders in that area. I think one of the things that we both realized is that from space, looking down at the Earth, you don't see those borders. All you see is the land masses.



Captain TRULY. This is looking down into the crater of Mount Fujiyama in Japan [slide 13]. There's Fujiyama with Tokyo just off to the right. This is also a good example of how well you could see the markings of man on Earth. All the large coastal cities of Japan show up clearly on this photograph. As a matter of fact, with the eyeball we very easily picked out, both in Japan and China, some of the intercoastal ways, the square markings of the people that lived on boats and piers over the years and had built up the bays so that they no longer held their natural contours.

Captain TRULY. This final slide is a beautiful one on our side of the world [slide 14]. This is looking south toward Baja, Calif. The large bay is Scammons Lagoon. It is in this lagoon that a family of about 1,000 gray whales mate each year. Today, as we have this hearing, this family is presently abeam the California coast, led by the pregnant females heading back to have their young in the bay this winter after spending the summer in Alaska.

Could we start the movie, please.

[Movie presentation.]

Colonel ENGLE. This is not an attempt by a couple of amateur pilots to learn skywriting. What you are seeing are the exhausts from the reaction control jets in response to the programed test maneuvers to look at the control margins and the stability margins of the vehicle during entry. The trailing white streamers, off the wings, occur on certain days when the moisture content in the sky is right because the pressure goes from the high pressure part of the wing to the low pressure on top. Moisture in the air is drawn out and forms contrails like that. It doesn't happen all the time.

The airplane is extremely solid and very predictable. From a pilot's standpoint, the Shuttle is a dream to fly and is a magnificent flying machine.

The outer glide slope on final approach is flown at 285 knots. We come down a 19-degree glide slope. At 1,700 feet, we begin the preflare maneuver to stop the steep rate of descent and exchange that energy to set up for the landing conditions. Here the speed dropped to 270 knots, and the approach is continued on down. The airplane slides down close to the ground to begin the float portion of the landing where air speed decreases between 5 to 6 knots a second. At the time of the landing, we touch down at 195 knots.

It was very windy and gusty at Edwards that day. We had hoped to get a crosswind landing to investigate and to demonstrate the crosswind capabilities of the vehicle. The winds unfortunately came up above what we had previously determined as our limit; so we retargeted to the runway that allowed us to land into the wind. We did not have a crosswind, but we did have gusty wind conditions. I must say that this bird penetrated those gusts to the extent that neither Dick nor I was aware that there was any turbulence or gusting in the air. It's a tremendous airplane and a super machine.

Our rollout was about 7,000 feet which was assisted to some extent by the winds that we had, about 20-knot winds on the surface of the lake that day. But, it certainly demonstrated that with the minimal braking, between 6 and 8 feet per second squared deceleration rate, that we are certainly going to be able to operate very easily and very handily out of existing runways anywhere around the country. This is a good view of the speed brakes on top of the rudder. The rudder itself splits open to form additional drag and help us slow the airplane and stop it faster.

Here is a view of the dry lake bed at Edwards Air Force Base also. You'll notice that it's about 7½ miles wide and 13 miles long. So it's a tremendous place to do the initial testing on this vehicle.

Captain TRULY. We are climbing out of the Shuttle 3 days early, coming home, and at this point feeling rather heavy after being in space for only a couple of days. But after we just walked around the vehicle and looked her over we felt a lot better. She looked like she was ready to go again.

The orbiter is down at Kennedy Space Center now getting carefully examined, and what modifications are required for the next flight are being done. [Applause.]

Colonel ENGLE. Mr. Chairman, that completes our presentation.

Mr. FUQUA. Thank you very much, Joe and Dick, and let me again congratulate you on a great successful flight even though it was abbreviated. I don't know any people probably any more disappointed than you were not getting that extra 3 days up there, but you did accomplish your mission and I think you are to be commended for the hard work and all that you did under abbreviated conditions for a very, very successful flight. We are all very proud and honored to have you today.

Mr. Winn has been able to join us now and he has a statement to make.

Mr. WINN. Thank you, Mr. Chairman.

I think Phil and Joe and Dick know how I feel about this mission. I feel like Don and I and Ron have been a part of the team

sitting behind the desk up here. We've been very, very interested. I want to congratulate you, and I want to congratulate Mary and Cody, for a great effort and a very successful flight. I'm afraid that possibly the press has not picked up the total success of this flight and how it is part of the first flight and the third flight, and possibly with your tours around the country you'll be able to impress on them and the American public that this was not a flop by any means whatsoever.

I want to congratulate you too on doing the public relations stint that is necessary, I suppose, by people wanting to meet you and ask you questions. Since we have people in the room and many Members of the Congress that want to ask some questions, I just want to add my congratulations for a job well done.

Colonel ENGLE. Thank you, sir.

Captain TRULY. Thank you, sir.

Mr. FUQUA. Mr. Flippo, do you have any questions?

Mr. FLIPPO. Mr. Chairman, I just want to thank these gentlemen for making this effort to push back those frontiers of the unknown that are absolutely essential to any society or any people who would want to help mankind, and your contributions are magnificent, and so far, when Columbus has come to Queen Isabella and asked for funds to continue to push that back, Isabella has not said no yet. I hope that that will continue to be true, and I'm sure it will be true of this committee.

Thank you.

Mr. FUQUA. Mr. Lowery.

Mr. LOWERY. Thank you, Mr. Chairman.

Indeed it was a spectacular event we've witnessed with the flights of *Columbia,* the world's first spaceship, because man not only goes into space on his own power, he returns flying back to earth, not falling like a rock, and I commend you for your contribution to that. I think history is going to look back on the early flights of *Columbia* as being every bit as significant as the voyages of Columbus and Magellan because we now have a vehicle with which to conquer space.

Mr. FUQUA. Mr. Nelson.

Mr. NELSON. Are you all planning to land No. 4 or No. 5 at Kennedy.

Colonel ENGLE. I believe the current plan is to land No. 5, but, that is an issue that is certainly under discussion at the present time.

Mr. MCGRATH. Will the gentleman yield?

Mr. NELSON. Certainly.

Mr. MCGRATH. Is that Kennedy Airport in New York?

Colonel ENGLE. No, sir.

Mr. NELSON. Hopefully not. Hopefully it's that 15,000-foot concrete runway, 350 feet wide, that you've landed on.

Colonel ENGLE. One of the things that we are going to have to do is get a crosswind landing before we go to Kennedy since there is only one runway there. We have to be able to land at Kennedy when we want to land there. So it's sort of dependent upon when we can get that crosswind landing.

Mr. NELSON. Are you planning to land on the concrete runway at Edwards instead of the desert floor?

Captain TRULY. Yes, sir. The plan is to land on the runway at Edwards if possible prior to committing to Kennedy.

Mr. NELSON. I see.

I noticed in some of the television coverage of you prior to the launch that all of the Rockwell people around you didn't have the mask over their face like they had when John and Crip flew. What was the story there?

Colonel ENGLE. As a step toward easier operations and based on the success we had with the health stabilization program for the first flight, we did clear fewer prime contacts and did relax some of the restrictions that we'd had before. That was the reason for that.

Mr. NELSON. Mr. Chairman, I just want to conclude by saying that I can't think of a finer birthday candle to light than was lit back at KSC.

Mr. FUQUA. It was quite a candle. Five, as a matter of fact.

Mr. McGrath.

Mr. MCGRATH. Thank you, Mr. Chairman.

I too would like to add and echo the congratulations to the crew and their wives, the crew at NASA and Rockwell and all the other contractors who put so much into the success of the mission.

I would like to also add that in spite and in addition to the technological triumph that it is, and certainly it is, that certainly this program and its success brings an awful lot of good feeling among the people in this country, and frankly I think part of what is lacking at times in this country is the fact that we don't have heroes any longer and you two guys exemplify, along with others in the astronaut corps, what's right about the heroes. You ought to be out promoting the program because you're the best people to do it.

I have one question. Last time there was quite a bit of damage done to the launch pad superstructure. I was wondering how much was done this time.

Captain TRULY. I'm afraid I can't answer that. I don't know.

Mr. CULBERTSON. There was less damage this time than was done the first time. I think, however, the stories were a little exaggerated by some of the press on the extent of the damage during STS–1. It wasn't as extensive as most of us anticipated it was going to be. It was even less during STS–2.

Mr. MCGRATH. Well, sometimes there can be a difference of opinion on how much damage when it comes to the dollars.

Was there anything unexpected in your preparations that you encountered this time, either through your own preparations or through the results of going through the first mission, that didn't come up? Something perhaps that was unexpected or totally unrelated to past experience.

Captain TRULY. Certainly, we didn't expect to have the failure of the fuel cell that we experienced. I think there was something good learned out of that, however. As you well know, we try to flight plan in a very conservative manner and there are a whole host of failures for which we had planned that abbreviated mission that we ended up doing. When we did experience the fuel cell failure, I felt that our flight control teams in Houston and the preflight planning that had been done prior to the flight served us marvelously well. That first day frankly was quite hectic in staying on the

time line for Joe and me. However, because of the good flight planning we were able to accomplish the shortened mission.

So in answer to your question, I would mention the fuel cell failure wasn't expected. I would also say that the fuel cell has now been removed from the *Columbia*. It has been disassembled and is being examined at the contractor's facility. The failure mechanism, as of this morning, has not been identified, but, it will be in the next few days. My prediction is that that fuel cell will fly in *Columbia* again.

Colonel ENGLE. I think from the standpoint of specifics and training, our preparations on that standpoint, we certainly did not experience any surprises. The training that we had and the briefings that John and Crip gave personally to us after their flight, I think, totally prepared us for that aspect of the flight.

Mr. MCGRATH. I think what we have to understand is that this is a test. These are test flights, these missions were. And what we are trying to develop here is not total success but success as far as establishing a system so that this thing can move in the future on a very, very quick turnaround basis.

Mr. CULBERTSON. Joe and Dick are too modest to say it, but one of the outstanding things that did happen on this mission was that we demonstrated, as we have a couple of times before, how extremely adaptable a crew can be when the timeline has to be changed because of some circumstance that happens along the way. They were really very burdened the first day and they responded in a truly superb manner that you don't sense from the casual way that they describe the mission and show pictures of them taking pictures. It's one of the significant things that we learned from this mission that we hadn't counted on.

Mr. MCGRATH. How about healthwise? You didn't do too much sleeping. You didn't do too much eating. As far as the tests when you came back, were there any blood levels, you know, things in the blood that were different? Weight loss? That type of thing?

Colonel ENGLE. I think that if anything did suffer from the abbreviated flight it was our sleep and our eating habits. We felt guilty every time we thought about going to sleep because of the number of things that we wanted to accomplish and had set our mind to accomplish in a 5-day flight plan. We wanted to get as much done in 2 days as we could. I think that we both felt that we could sleep and eat when we got back after the mission and accomplish these tasks while we were up there. In view of that I think I particularly became trapped by a lack of appreciation of dehydration. I lost about 8 pounds on the flight. But, we were still able to function.

Mr. MCGRATH. Well, sleeping and eating are part of the system which aren't developed. I mean, if we are going to have extended use of the orbiter in space, then we're going to have to learn how to sleep and eat on the flight too.

Colonel ENGLE. Obviously on this flight we could have elected to do it differently. Frankly, we found it easy to sleep very soundly. One of the problems with sleeping was if you happened to wake up and look out the window that was it for about an hour or two because it was such a beautiful view that you were wide awake again.

Mr. MCGRATH. No noise either.

Thank you very much, gentlemen.

Mr. FUQUA. Mr. Hall.

Mr. HALL. I think I would be remiss if I didn't express just my profound gratitude to you and really the sense of personal accomplishment that I think every American felt as they saw the launch and saw the successful return.

I'm an old Navy pilot and I well remember the first time I was catapulted off the end of a carrier, screaming and trying to get my goggles fixed.

From the standpoint of levity, let me impart to you an old story that I heard aboard ship, and that is that they used to take their women to sea and the women became enceinte on some occasions, and when the end of the 9 months approached, if they couldn't produce, sometimes they would walk them by the big guns and fire the guns off and cause the launch of the child. That's where the term son of a gun came from. [Laughter.]

I really wonder if you see any benefits in space flight medically. [Laughter.]

Colonel ENGLE. I'll yield to the PLT on that.

Mr. HALL. Seriously, we thank you very much. I came within 31 seconds of seeing this launch and some folks from my office did get to observe it and we're very appreciative. Thank you so much.

Mr. FUQUA. Thank you, Ralph.

Mr. Dunn.

Mr. DUNN. I would just echo what Mr. McGrath said about American heroes. I have three small children, and what you have done is an intangible. We spend a lot of time on this committee talking about money, but what you have done is an intangible for the young people of this Nation to restore their belief in what we can do. We owe you a deep sense of gratitude.

I have one technical question. The air brakes which you showed right at the end of the movie which pop out on the rudder, fairly standard on commercial aircraft in which the flaps come up to become air brakes. But given the size of that aircraft and the weight and the small proportion that the wings and rudder are to that aircraft, are they really making any difference in that stopping ability?

Colonel ENGLE. Yes, they do. They aid probably as much in alleviated loads on the main landing gear to have those speed brakes deployed as the nose is coming down. They do help to some extent in deceleration. They quite frankly aid more in modulation of energy on the final approach and in the pattern. Since the vehicle does not have any power at that point in the profile, all the energy modulation is done either by changing the lift-to-drag ratio by velocity or by terms of modulating drag with the speed brakes.

Mr. DUNN. You mentioned there that you actually tested the capability to adjust to, I assume you are talking about, length of runway and placement of the runway as you're coming down and making your approach and giving you some flexibility as to where exactly, what point you are going to touch down on this flight, which you didn't do on the second flight, is that true? Were you firing the engines momentarily?

Colonel ENGLE. No, sir. The tests that we were doing were primarily to determine the stability and the control derivatives of the vehicle in flying up and away.

Mr. DUNN. We still don't have any flexibility then in which we decide that we are going to come out of this orbit and we are going to land there. Are you saying we still don't have the ability to change our mind and go to a different place?

Colonel ENGLE. Oh, yes, sir, we sure do. I didn't mean to imply that we couldn't. No, we can retarget the different runways. In fact we did retarget to different runways on the lake bed itself after we had committed to the deorbit burn because the winds did come and exceeded the amount of crosswind that we wanted to attempt on the first crosswind landing.

Mr. DUNN. I thank you.

Mr. FUQUA. We are very happy to have joining us today Congressman O'Brien, from Illinois, who is not a member of our committee but is very interested in the program.

George, do you have any questions?

Mr. O'BRIEN. Thank you, Mr. Chairman.

Joe and Dick, I'd simply like to congratulate you on completing a difficult round in par. I'm glad you didn't need a mulligan. I again want to extend my thanks to Dick for coming out to my town of Joliet in 1976. He was our Bicentennial speaker. He looked good then, you looked good in the flight, and you look good right now.

Captain TRULY. Thank you, sir.

Mr. FUQUA. Thank you.

Again we want to thank you and congratulate you on a very successful flight, and I think it has been mentioned by Mr. McGrath that this is only the second flight of four test flights before we hopefully go operational. We have to learn the personality of that bird during that time. That's what it's all about. We think the problems of the oil, the fuel cell, hopefully we won't ever have a problem with that again because we better understand that. That's why we have test flights, why we have very capable people such as you performing that. Phil Culbertson mentioned that you were able to perform very well the mission and accomplish in 2 days what you had set out to accomplish in 5 days. So I think it's a great achievement and a compliment to you, the achievements that you made in space, and we're just very proud and congratulate you again and hope you get a flight again soon so you can get that full mission in.

Colonel ENGLE. Thank you, Mr. Chairman.

Mr. FUQUA. Thank you very much. The hearing will adjourn.

[Whereupon at 11 a.m. the hearing was adjourned.]

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